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A strategy for sustainable outcomes assessment across a mechanical engineering curriculum that maximizes faculty engagement

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Disciplines
Engineering Education | Mechanical Engineering

Comments
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AC 2012-5154: A STRATEGY FOR SUSTAINABLE OUTCOMES ASSESSMENT ACROSS A MECHANICAL ENGINEERING CURRICULUM THAT MAXIMIZES FACULTY ENGAGEMENT

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Abstract

As part of continuous improvement of the program and ABET accreditation requirements, direct assessment methods of student outcomes are necessary and quite illustrative in terms of describing student learning. Direct assessment methods range from evaluating student performance on locally prepared examinations or standardized tests to assessing student portfolios or performing performance appraisals. Choice of the methods depends on a range of factors including number of students in the program, impact on faculty workload and appropriateness of sample size. One of the challenges in implementing a successful direct assessment process is engaging the faculty and achieving a high level of participation and support. Here we describe the development and successful implementation of direct assessment processes for a large mechanical engineering program with 1340 students and 36 faculty at a land-grant, research intensive doctoral granting university. This process was piloted in Spring 2011 to identify potential issues, which were addressed and is now fully implemented. Assessment of the process itself indicates high level of faculty satisfaction and involvement, suggesting that the process is a sustainable one.

Introduction

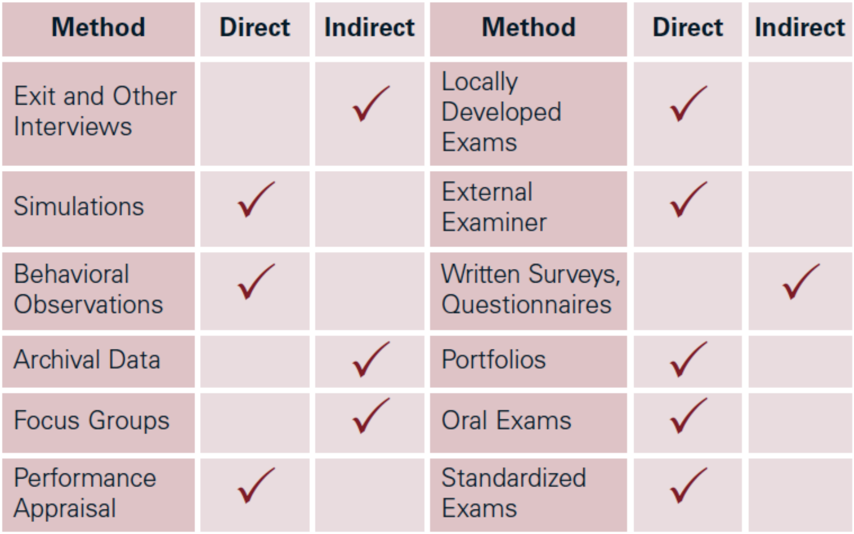
Continual self-evaluation and improvement of instruction-related activities is critical to maintaining excellence in an undergraduate educational program.[1] In recognition of this fact, accreditation bodies (e.g. ABET for engineering) typically emphasize the establishment of such a process as a requirement for accreditation. For engineering programs, ABET has established a set of General Criteria for Baccalaureate Level Programs that must be satisfied by all programs to be accredited by the Engineering Accreditation Commission.[2] These criteria are intended to assure quality and to foster the systematic pursuit of improvement in the quality of engineering education that satisfies the needs of constituencies in a dynamic and competitive environment.

Amongst these criteria are the establishment of program educational objectives (criteria 2), student outcomes (criteria 3) and a continuous improvement process (criteria 4) that regularly uses appropriate, documented processes for *assessing* and *evaluating* the extent to which both the program educational objectives and the student outcomes are being attained. The nomenclatures of terms are given below for clarity. Program educational objectives are broad statements that describe what graduates are expected to attain within a few years of graduation. Program educational objectives are based on the needs of the program's constituencies. Student outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program. Student outcomes are often referred to as ABET a-k outcomes. In addition program specific outcomes may exist. For example, the American Society of Mechanical Engineers (ASME) specifies some outcomes in addition to ABET a-k.[2] Typically program objectives map to student outcomes, which then map in some way map to the student outcomes.

Assessment is one or more processes that identify, collect, and prepare data to evaluate the attainment of student outcomes and program educational objectives. Effective assessment uses relevant direct, indirect, quantitative and qualitative measures as appropriate to the objective or outcome being measured. Appropriate sampling methods may be used as part of an assessment process. Evaluation is one or more processes for interpreting the data and evidence accumulated through assessment processes. Evaluation determines the extent to which student outcomes and program educational objectives are being attained. Evaluation results in decisions and actions regarding program improvement.

It is generally accepted that a combination of direct and indirect methods in assessing an outcome are necessary.[3] A summary of commonly used methods and their classification is shown in Fig. 1. It can be seen that in general, direct assessment methods are more effort and time intensive and often become the bottleneck in an assessment process. This is often primarily due to the demand on faculty and staff time, which leads to frustration and subsequently resistance in faculty participation, which eventually undermines the intent to uphold excellence in the educational effort. Since the faculty deliver the educational programs, it is essential to have them fully vested in the process. Therefore in order to truly be effective, the assessment and evaluation processes should be aligned with faculty efforts in the educational enterprise and minimize faculty effort.[4] This is especially important in the case of programs that are part of research intensive, doctoral granting institutions, where the research enterprise can impose additional constraints on time and effort.

This paper describes the development and successful implementation of a sustainable direct assessment process to measure attainment of student outcomes (summative assessment) for a large mechanical engineering program at a land-grant doctoral granting, highly research-active university.



Method	Direct	Indirect	Method	Direct	Indirect
Exit and Other Interviews		✓	Locally Developed Exams	✓	
Simulations	✓		External Examiner	✓	
Behavioral Observations	✓		Written Surveys, Questionnaires		✓
Archival Data		✓	Portfolios	✓	
Focus Groups		✓	Oral Exams	✓	
Performance Appraisal	✓		Standardized Exams	✓	

Figure 1: Classification of commonly used assessment methods (abet.org).

State of the mechanical engineering program

Iowa State University's first diploma awarded in 1872 was in the discipline of "mechanic arts, including mechanical engineering." Since then, the mechanical engineering program's impact has continued to grow, with its first accreditation in 1936. Currently, the American Society for Engineering Education ranks the department among the top ten programs nationally in terms of bachelor's degrees awarded. As of Fall 2011, the mechanical engineering program at Iowa State University had an enrollment of 1,340 undergraduate students. There are currently thirty tenure track faculty members, including the department chair and the dean of the college, as well as six full time and part time lecturers.

Motivation for change in assessment processes

An assessment and evaluation process established in 2003 and refined in 2007 proved difficult to sustain past primarily due to two major factors:

- Highly data and faculty-time intensive assessment process: The process involved performing direct assessment on every course outcome in every departmentally administered course. Moreover it was suggested that this process be performed every year. One can easily imagine the level of effort involved in such a process. In addition it was not clear what could be learnt from this large amount of data.
- Inefficient oversight: A highly complex and layered oversight system with high level of distributed responsibility led to a complicated sense of ownership of the deliverables. This loose oversight system was typically not active in engaging and reminding the faculty of their responsibilities.

With the program enrollments and faculty size continuing to grow, there was an obvious need to establish a more sustainable assessment and evaluation process and oversight structure for long term impact. Departmental leadership participated in several national workshops in 2010, to learn best practices for sustainable assessment. As a result, new assessment and evaluation processes were established in Fall 210 by engaging faculty and the industrial advisory council throughout the development and implementation process. The underlying philosophy was to focus on summative assessment of the program and minimize faculty and staff burden.

New oversight structure and division of responsibility

The current oversight structure, which was implemented in Summer/Fall 2010 leverages existing leadership positions in the department and the existence of Course Development Committees (CDCs) for the core curriculum courses, is shown in Fig. 2. The CDCs typically consist of the instructors who usually teach a particular class. Each CDC is responsible for implementing major changes to a particular courses.

The oversight responsibility primarily resides with the Associate Chair for Undergraduate Studies and an assessment coordinator. Both individuals have a continuing formal responsibility for oversight of the assessment and evaluation process as defined in their position responsibility statements. One of these individuals also sits on the College of Engineering ABET committee and facilitates exchange of information and promotion of collaborative efforts in assessment and evaluation that may be pertinent to accreditation.

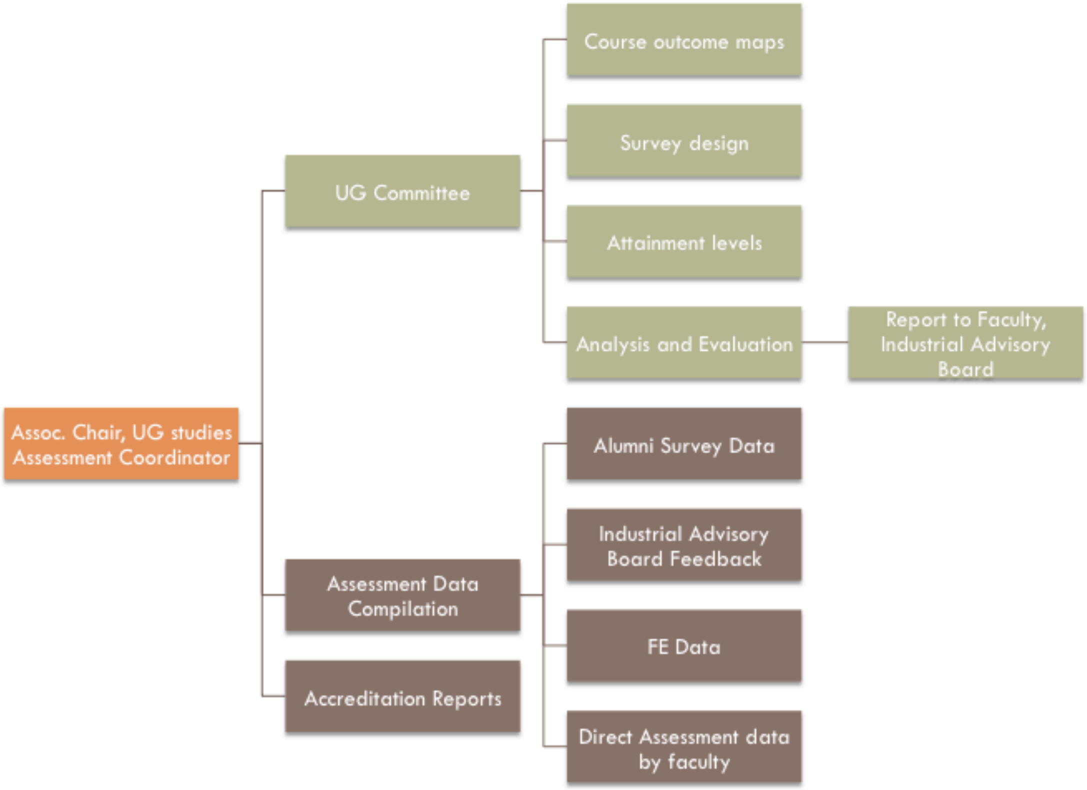


Figure 2: Current oversight structure and division of responsibilities established in 2010.

The Associate Chair for Undergraduate Studies also chairs the Undergraduate Education Committee (UGEC) that is comprised of faculty who are Course Development Committee Chairs, the assessment coordinator and a staff support member. This committee is responsible for recommending assessment and evaluation process changes, evaluating the assessment data and recommendations for changes to curriculum. These are then presented to the faculty and the industrial advisory council of the department for feedback and finalization. The entire faculty then vote on any proposed changes to the curriculum. Finally, the Associate Chair, assisted by the assessment coordinator, is responsible for reviewing the assessment/evaluation process and make changes as necessary. These two individuals are also responsible for spearheading reporting related to accreditation. By concentrating responsibility with two individuals, ownership of the processes is clear.

Change process

As is typically done in most programs, indirect assessment of course outcomes was already being carried out in the program through a student survey at the end of each semester. Students were asked to assess their opportunities to attain student outcomes in each core course. The department adopted the use of an online survey system in Fall 2010 upon the recommendation of the UGEC due to the advantages in data parsing and reporting afforded by electronic data. The most important aspect of the process change was related to establishing a new direct assessment process to measure attainment of student outcomes. Based upon other existing studies and information learnt from the assessment workshops, it was decided to use two major tools for direct assessment – course outcomes assessment and FE morning exam data. Course outcomes assessment is pertinent because in most programs, course outcomes (established by faculty) can be mapped to student outcomes (ABET a-k and ASME outcomes) as shown in Fig. 3. Therefore attainment of student outcomes can be demonstrated by demonstrating attainment of course outcomes. This principle can thus be applied to any curricular structure since it is aimed at assessing outcomes at the course level.

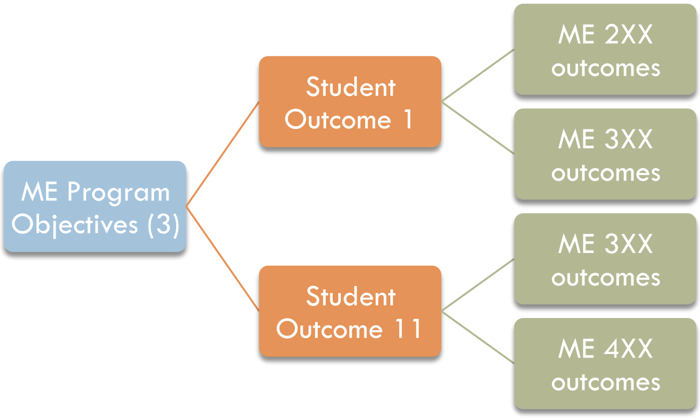


Figure 3: The relationship between course outcomes (far right), student outcomes (center) and program educational objectives.

Mapping course outcomes to student outcomes

Accordingly the first task was to engage the faculty in mapping each course outcome to student outcomes. The oversight team tasked each CDC to establish a set of course outcomes that reflect the most important topics to be covered by the class, irrespective of who would teach them. Faculty could then additional course outcomes as necessary to reflect personal interest and expertise, but only above and beyond the common outcomes. This process appealed to the faculty and the CDCs were able to complete this task fairly quickly. Next, the CDCs were asked to map the common course outcomes to the 11 student outcomes for the program (ABET a-k and ASME). Instead of a simple map, they were also asked to prioritize (rank order) their course outcomes in the mapping. The CDCs completed these two tasks in a 2-4 week timeframe and the overall process engaged all faculty involved in teaching the courses, which corresponded to 33 faculty (~92% of the faculty). An example of the mapping for a junior-level core course in engineering measurements is shown in Figure 4. The CDC for the course comprising of three faculty members established this particular map.

Once all the mappings were established, the next task was to determine which outcomes should be assessed in order to be able to evaluate attainment of student outcomes. The intent was to spread the outcomes assessment across the curriculum and avoid unnecessary redundancy in data collection. In this regard, the UGEC determined that assessment would be performed in nine core courses ranging from the sophomore to the senior level, including the capstone design experience courses.

Course Outcome (below)/ Student Outcome (right)	(a) An ability to apply knowledge of mathematics, science, and engineering	(b) An ability to design and conduct experiments, as well as to analyze and interpret data	(c) An ability to design a system, component, or process to meet desired needs within realistic	(d) An ability to function on multidisciplinary teams	(e) An ability to identify, formulate, and solve engineering problems	(f) An understanding of professional and ethical responsibility	(g) An ability to communicate effectively	(h) The broad education necessary to understand the impact of engineering solutions in a global,	(i) A recognition of the need for, and an ability to engage in life-long learning	(j) A knowledge of contemporary issues	(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering
1. Understand basic theory related to the engineering measurement process.	X								X		
2. Understand the role of sampling and signal conditioning in enhancing measurements.	X				X						
3. Recognize a measurement system's dynamic limitations by understanding first-order and second-order behavior, and to characterize frequency response.	X		X		X						
4. Apply rigorous data treatment procedures such as statistical and error propagation methods to experimental results, thereby allowing objective and accurate data interpretation.	X	X									
5. Synthesize theoretical knowledge to perform experiments and recognize practical aspects of engineering measurements	X	X	X		X						
6. Develop effective communication skills by engaging in verbal interaction with team members and by submitting succinct and descriptive written reports.				X			X				
7. Appreciate measurement and instrumentation in the context of contemporary issues.									X	X	

RANK ORDER	1	2	6	8	3		7		9	5	4

Figure 4: Example of a prioritized map of course outcomes to student outcomes for a junior-level core course on engineering measurements.

The choice of courses was primarily determined by the need to ensure 1) almost all graduating students went through the course and 2) sufficient coverage of thermal systems and mechanical systems were attained and; 3) sufficient courses from sophomore to senior levels were attained. The rank orders provided by the various CDCs helped in determining the assessment map. After some optimization by the UGEC, which took two weeks, the final assessment matrix was established as shown in Fig. 5 and approved by the faculty. A shaded checkbox indicates an assessed outcome for a given course. As the figure shows, each course is responsible for performing assessment on no more than three outcomes, thus minimizing faculty effort. Moreover, since these outcomes were based on faculty-ranked importance for a given course, faculty are more likely to actively participate in the assessment as it provides them with information on student learning regarding topics they feel are critical for a given course. The figure shows that most student outcomes are being assessed in two different courses to avoid any unintentional bias in results from one course. The only exceptions are the student outcomes related to contemporary issues and ethics, which are assessed in only one course each.

Assessing ASME and design requirements

ASME specifies that in addition to ABET a-k, Mechanical Engineering programs must demonstrate that their graduates have the ability to apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations) to model, analyze, design, and realize physical systems, components or processes; and work professionally in both thermal and mechanical systems areas. From Figure 5, it can be seen that several of the student outcomes pertaining to the ASME requirement are being assessed in courses that have emphasis in mechanical systems (M) and thermal systems (T).

Student Outcomes	Soph. Des.	Manu-fact.	Mach. Des.	Thermo	Fluid Flow	Engg. Meas.	Dyn. Sys. & Controls	Heat Trans.	Capstone Des.
	Soph.	Junior					Senior		
(a) An ability to apply knowledge of mathematics, science, and engineering	✓	✓	✓	🟧 ✓(T)	🟧 ✓(T)	🟧 ✓ (M)	🟧 ✓ (M)	✓	✓
(b) An ability to design and conduct experiments, as well as to analyze and interpret data		✓(M)			🟧 ✓(T)	🟧 ✓ (M)	🟧 ✓(M)	🟧 ✓(T)	
(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	✓		🟧 ✓ (M)			✓	✓	🟧 ✓(T)	✓
(d) An ability to function on multidisciplinary teams	🟧 ✓	✓	✓			✓	✓	✓	🟧 ✓
(e) An ability to identify, formulate, and solve engineering problems		🟧 ✓ (M)	✓	🟧 ✓(T)	✓	✓	✓	✓	
(f) An understanding of professional and ethical responsibility	✓		🟧 ✓						
(g) An ability to communicate effectively	🟧 ✓	✓	✓			✓	✓	✓	🟧 ✓
(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	🟧 ✓	✓	✓	🟧 ✓			✓		
(i) A recognition of the need for, and an ability to engage in life-long learning	✓	🟧 ✓	✓			✓			🟧 ✓
(j) A knowledge of contemporary issues		✓	✓			🟧 ✓	✓		
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	✓	🟧 ✓ (M)	✓		🟧 ✓(T)	✓	🟧 ✓ (M)	🟧 ✓(T)	✓
(ASME) The ability to: apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations) to model, analyze, design, and realize physical systems, components or processes; and work professionally in both thermal and mechanical systems areas.	Incoporated into outcomes (a), (b), (c), (e) and (k) as indicated by thermal (T) and mechanical (M)								

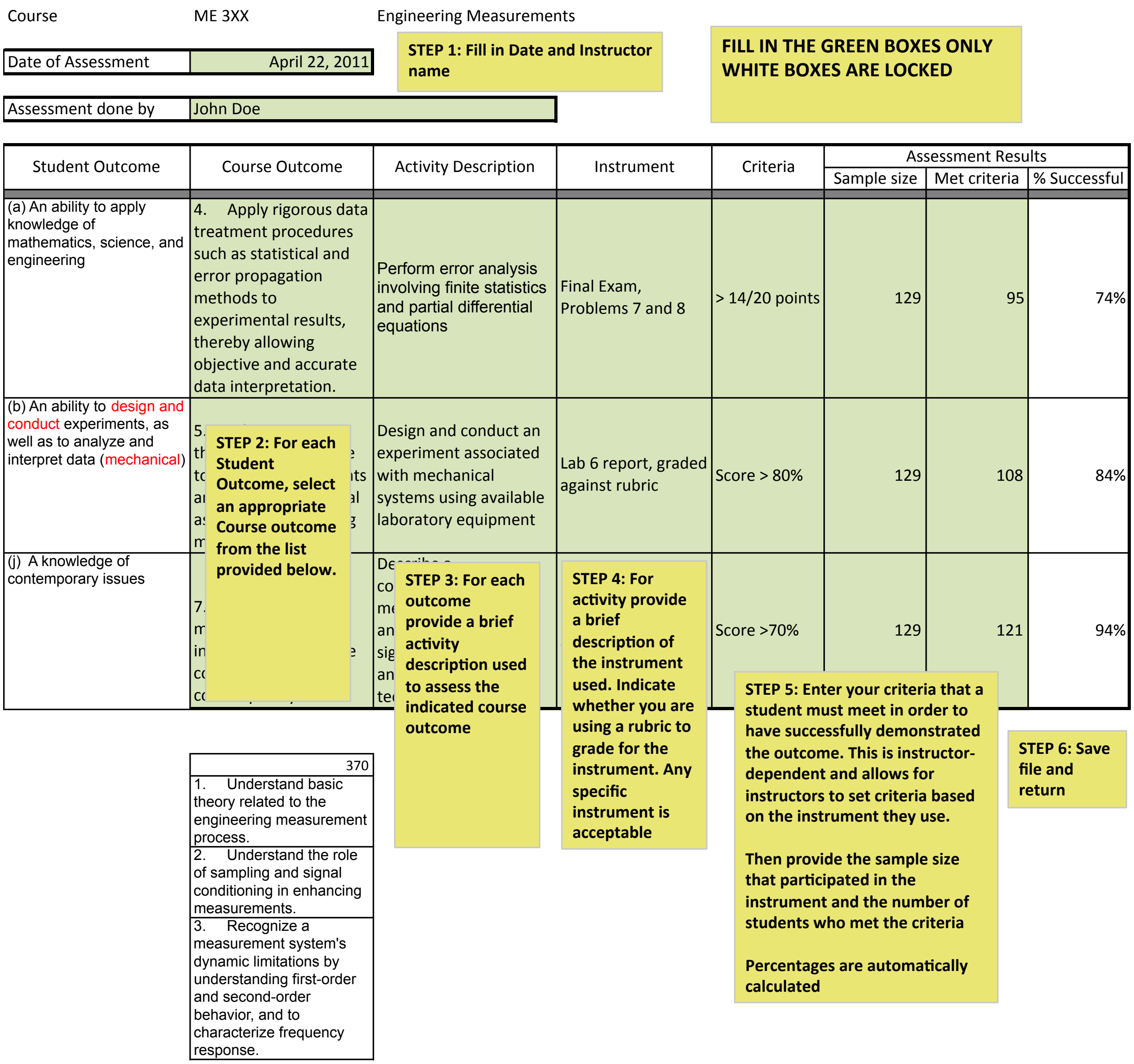
✓ indicates course outcome maps to student outcome
🟧 ✓ indicates course will directly assess this particular outcome

Figure 5: Course assessment matrix for the curriculum. Each core course is responsible for assessing no more than three outcomes.

Our ME curriculum offers multiple tracks for the senior capstone design experience – mechanical systems, HVAC systems and appropriate technologies design. Each course, while adhering to common elements of team-based experience and the use of multiple realistic design constraints, have varying emphasis on mechanical or thermal systems design. Consequently the capstone courses could not be used to measure attainment of the design related student outcomes, especially when considered together with the ASME requirements. Consequently a design experience was incorporated into two existing required courses - machine design (mechanical systems) and course and a heat transfer course (thermal systems) to ensure that ALL students underwent an experience in designing a mechanical system and a thermal system.

Aligning course outcomes assessment with student evaluation in courses

The next step was to establish guidelines for performing direct assessment of course outcomes in a given course that again minimized faculty effort. One effective method is to align the assessment with an evaluative component that the instructor already performs in the class. In order to do this, each instructor is asked to map a course outcome to a particular student activity/evaluative component. Examples include a particular problem on an exam, a homework, a project report etc. This approach is consistent with the notion of direct assessment and leverages the fact that the instructor is going to evaluate the chosen component irrespective of the assessment need, since it contributes to the course grade. The instructor is also asked to set a criteria that reflects the demonstration of the particular outcome. For example an instructor, having chosen a homework on uncertainty analysis as the activity to reflect ability to apply knowledge of mathematics and engineering, may set the criteria for attainment as a 75% score on the HW. This criteria is instructor dependent since instructors are in best position to judge the difficulty level of the problem. Finally the instructor simply reports the number of students who met this criteria. This exercise is facilitated through the use of an excel spreadsheet that guides the instructor through the process and minimizes effort. An example of an outcomes assessment spreadsheet is shown below in Fig. 6.



Course	ME 3XX	Engineering Measurements
Date of Assessment	April 22, 2011	
Assessment done by	John Doe	

STEP 1: Fill in Date and Instructor name

FILL IN THE GREEN BOXES ONLY WHITE BOXES ARE LOCKED

Student Outcome	Course Outcome	Activity Description	Instrument	Criteria	Assessment Results		
					Sample size	Met criteria	% Successful
(a) An ability to apply knowledge of mathematics, science, and engineering	4. Apply rigorous data treatment procedures such as statistical and error propagation methods to experimental results, thereby allowing objective and accurate data interpretation.	Perform error analysis involving finite statistics and partial differential equations	Final Exam, Problems 7 and 8	> 14/20 points	129	95	74%
(b) An ability to design and conduct experiments, as well as to analyze and interpret data (mechanical)	5. th e to ts ar al as g m	Design and conduct an experiment associated with mechanical systems using available laboratory equipment	Lab 6 report, graded against rubric	Score > 80%	129	108	84%
(j) A knowledge of contemporary issues	7. m in e co co	De co me an sig an te		Score >70%	129	121	94%

STEP 2: For each Student Outcome, select an appropriate Course outcome from the list provided below.

STEP 3: For each outcome provide a brief activity description used to assess the indicated course outcome

STEP 4: For activity provide a brief description of the instrument used. Indicate whether you are using a rubric to grade for the instrument. Any specific instrument is acceptable

STEP 5: Enter your criteria that a student must meet in order to have successfully demonstrated the outcome. This is instructor-dependent and allows for instructors to set criteria based on the instrument they use.

Then provide the sample size that participated in the instrument and the number of students who met the criteria

Percentages are automatically calculated

STEP 6: Save file and return

370
1. Understand basic theory related to the engineering measurement process.
2. Understand the role of sampling and signal conditioning in enhancing measurements.
3. Recognize a measurement system's dynamic limitations by understanding first-order and second-order behavior, and to characterize frequency response.

Figure 6: An excel spreadsheet used by instructors to provide assessment data.

Each course (instructor) provides assessment data in a spreadsheet and the assessment coordinators will compile the data and present to the UGEC for discussion and evaluation. Twelve (12) faculty involved in teaching the courses performed assessment. They were extremely supportive of this format for providing data. They expressed satisfaction at the clear visual guides (colors) and the fact that the pre-set mapping of the outcomes (that they had help set) provided the context and clarity on the reporting requirements. The use of spreadsheets with fixed contents allows the possibility of writing automated scripts to gather and compile the data, which is one of the on-going activities in the department.

Tools and instruments used for direct assessment

The faculty are encouraged to use instruments and activities that are already in place for evaluation of student performance, such as exams, homework, quizzes, lab activities/reports, project presentations, design reports etc. For lab reports and design projects, rubrics were the most common tool used to assign quantitative measures.

In addition to course outcomes assessment, the UGEC also decided to use the FE morning exam data as another direct assessment measure. This also provides some information regarding the abilities of our students on a national level and allows a broader assessment of the effectiveness of our curriculum. The specific components we look at include 1) Mathematics and Probability/Statistics scores (ABET outcome a); 2) Thermodynamics and Chemistry (ABET outcome b); 3) Ethics and Business Practice (ABET outcome f). We typically use the metric of meeting or exceeding the national score each component. About 46% of our graduates take the exam annually.

New activities to measure outcomes in courses

One major benefit of the outcomes mapping process with high faculty engagement was the identification of areas of improvement in the curriculum. A list of issues identified during this process and the steps taken to address them through changes to the curricular content of a particular course are listed in Table 1.

Assessment and Evaluation cycles

In order to effect continuous improvement, a periodic assessment and evaluation cycle is necessary. It is well established that assessment and evaluation every year is unnecessary.[3] In fact having a periods that is 1-2 years in most cases can provide sufficient time for any changes resulting from evaluation to persist and reduce the burden on faculty and staff effort. The cycles that we arrived at are listed below. Only the course surveys (conducted online) are done every semester, as it is largely automated and has minimal impact on effort. Moreover this system is used for faculty teaching evaluations and hence is administered every semester.

Summary and Feedback on process

Faculty feedback and observations of the oversight team were the primary forms of assessment performed on the overall process. Faculty feedback was obtained through discussions in faculty meetings. The key points arising from the discussions are summarized below:

- Faculty members liked the focus on measuring a specific number of outcomes in a given course and were more satisfied with the related workload compared to evaluating all course outcomes. Twelve faculty participated in the pilot semester. On average faculty spent about 4 hours on assessment activities for a given course. The times spent ranged from 1 hour for a lab course that had teaching assistants to 12 hours for capstone design courses. Faculty commented that the time spent was less than expected. Aligning assessment efforts with faculty efforts in courses helped in this regard.

- Faculty members were satisfied with the process of engagement at the course levels to determine a common set of outcomes between faculty who teach the course.
- Overall the faculty members felt that this process would be sustainable. The primary reasons for this were identified a workload-related - the fact that the outcomes assessment in each course was well aligned with their evaluation of student performance and the notion of staggering the course outcomes assessment across two years (i.e. avoiding assessment in every course in every semester).

Table 1: Specific changes to curricular content made as a result of observations made by faculty during mapping process

Issue identified during mapping	Curricular change to address issue
1. No opportunity for all students to participate in a mechanical systems design experience AND thermal systems design experience	Implemented a design experience in a machine design course and heat transfer.
2. Almost all lab experiences focused on conducting experiments (specific instruction-driven) and analysis of data. There were no opportunities for students to design/construct their own experimental procedure.	Two inquiry-based laboratory exercises were designed and implemented in an engineering measurements class and a fluids class. In both these exercises, students were posed a question to answer. Students would then design an experiment to gather the necessary data to answer the question without any specific instructions on what to do.
3. Challenges in measuring competency in knowledge of contemporary issues	A specific exercise created in the engineering measurements class to visit state-of-the-art facilities on campus and learn about advances in engineering measurements, analysis and the broader problems they are being used to solve. Students write a report that is graded against a rubric.
4. Lack of focus on using modern engineering tools in thermal fluids classes	Heat transfer class incorporated analysis activities using computational fluid dynamics (CFD)

Table 2: Tools used for outcomes assessment

Assessment tool	Assessment Cycle	Evaluation Cycle	Notes on sample size
Course surveys	Every semester	Every two years	Survey is online- response rate is 80% of all enrolled students
Course outcome assessment (mapped to student outcomes)	Every three years	Every three years	Data is typically provided for all students enrolled in the courses.
FE morning exam data	Every year	Every 5 years	Over the last 10 years, about 46% of ME graduates take the FE exam annually

From the perspectives of the oversight committee, the following observations were made:

- Departmental leadership should continue to maintain a focused oversight structure (1-2 individuals). This helps in maintaining an effective stream of communication and ensures proper follow through on faculty tasks.
- Move towards a web-based system (that can leverage the current spreadsheet format or adapt it) for the course outcomes assessment to further increase efficiency and tracking
- Provide periodic dialogue between faculty related to best practices in assessment so that faculty can be cognizant of the latest developments in this area and leverage them for their own assessment practice
- Find ways to increase student participation in the FE exams to increase confidence in using the data for assessment purposes

Summary and outlook

This paper described the development and successful implementation of direct assessment processes for a large mechanical engineering program with 1340 students and 36 faculty. An emphasis was placed on maximizing faculty involvement in establishing and implementation of the process while minimizing faculty effort during the assessment process itself. This process was piloted in Spring 2011 to identify potential issues, which were addressed and is now fully implemented. Assessment of the process itself indicates high level of faculty satisfaction and involvement, suggesting that the process is a sustainable one. Specific next steps are to evaluate the data for program improvement purposes and investigate moving towards a web-based platform for gathering and storing the course outcomes assessment data.

References

[1] B.M. Olds, B.M. Moskal and R.L. Miller, 'Assessment in Engineering Education: Evolution, Approaches and Future Collaborations,' *Journal of Engineering Education*, v94, 2005, p. 13.

[2] Criteria for Accrediting Engineering Programs, 2012-2013, www.abet.org.

[3] G. Rogers, 'Assessment for continuous improvement: What have we learned?' *International Journal of Engineering Education*, v18, 2002, p.108.

[4] J.C. Morales, 'Implementing A Robust, Yet Straightforward, Direct Assessment Process That Engages 100% Of The Faculty,' *Proceedings of 2009 ASME International Mechanical Engineering Congress and Exposition*, Lake Buena Vista, FL, 2010, v7, p. 25.